

Rules for LNG Ships and Barges Equipped with Regassification Systems

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A guide to the Rules

and published requirements

Rules for LNG Ships and Barges Equipped with Regasification Systems

Introduction

The Rules are published as a complete set.

Rules updating

The Rules are published periodically and changed through a system of Notices between releases.

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■ Section 1

General

1.1 Goal

1.1.1 The goal of these Rules is to provide for the safe regasification of liquefied natural gas (LNG), minimising the risk to the ship or barge (hereinafter referred to as 'ship'), its crew and to the environment by specifying requirements for the design, construction and installation of regasification systems on board LNG ships having regard to the nature of the products including flammability, toxicity, asphyxiation, corrosivity, reactivity, temperature and pressure.

1.2 Application

1.2.1 The requirements of these Rules apply to LNG ships meeting the requirements of the *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquefied Gases in Bulk* (hereinafter referred to as the Rules for Ships for Liquefied Gases) that are equipped with regasification systems and associated arrangements.

1.2.2 The requirements are in addition to the applicable requirements of the *Rules and Regulations for the Classification of Ships* (hereinafter referred to as the Rules for Ships), and to the applicable requirements of the Rules for Ships for Liquefied Gases.

1.2.3 Dependent on ship service and regasification operational location, requirements additional to these Rules may be imposed by the National Authority with whom the ship is registered and/or by the Administration within whose territorial jurisdiction the ship is intended to operate.

1.2.4 The Rules do not repeat the general requirements for fire safety as stated in statutory conventions. These Rules do, however, include fire safety requirements additional to those stated in the statutory conventions that are specific to the construction and equipment of regasification systems.

1.2.5 Unless requested, classification will not include those systems which are additional to the 'send-out' process plant equipment such as blending facilities, odorisers, or dew point correction/dehumidification, except where the design and/or arrangements of such equipment and piping may affect the safety of the vessel.

1.3 Class notations

1.3.1 The following notations may be assigned as considered appropriate by the Classification Committee, on application from the Owners:

✳ **Lloyd's RGP** (Regasification Plant) – This notation will be assigned when a regasification system and arrangements have been constructed, installed and tested under Lloyd's Register's (hereinafter referred to as LR's) Special Survey and in accordance with the relevant requirements of the Rules.

✳ **Lloyd's RGP+** (Regasification Plant Plus) This notation will be assigned when a regasification system and arrangements have been constructed, installed and tested under LR's Special Survey and in accordance with the relevant requirements of the Rules and the system is configured to allow continuing operation in the event of a single failure.

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1.4 Survey

1.4.1 The regasification system and its sub-systems and equipment shall be installed and tested to the Surveyor's satisfaction.

1.4.2 All regasification systems shall be subject to the following surveys:

- (a) an Initial Survey before the regasification system is put into service, which should include a complete examination of its structure, equipment, fittings, arrangements and materials of the regasification system. This survey should be such as to ensure that the structure, equipment, fittings, arrangements and material fully comply with the applicable provisions of these Rules;
- (b) a Renewal Survey at intervals specified by LR, but not exceeding 5 years. The Renewal Survey should be such as to ensure that the structure, equipment, fittings, arrangements and material fully comply with the applicable provisions of these Rules and are in good working order;
- (c) an Intermediate Survey within 3 months before or after the second anniversary date or within 3 months before or after the third anniversary date of the Certificate which should take the place of one of the annual surveys specified in *Ch 1, 1.4 Survey 1.4.2.(d)*. The Intermediate Survey should be such as to ensure that the safety equipment, and other equipment, and associated pump and piping systems fully comply with the applicable provisions of these Rules and are in good working order;
- (d) an Annual Survey within 3 months before or after each anniversary date of the Certificate, including a general inspection of the structure, equipment, fittings, arrangements and material of the regasification system to ensure that they have been maintained in accordance with *Ch 1, 1.4 Survey 1.4.6*, and that they remain satisfactory for the service for which the ship is intended;
- (e) an additional survey, either general or partial according to the circumstances, should be carried out when required after an investigation prescribed in *Ch 1, 1.4 Survey 1.4.8*, or whenever any important repairs or renewals are made. Such a survey should ensure that the necessary repairs or renewals have been effectively made, that the material and workmanship of such repairs or renewals are satisfactory, and that the ship is fit to proceed to sea without danger to the ship or persons on board or without presenting unreasonable threat of harm to the marine environment.

1.4.3 Surveys referred to in *Ch 1, 1.4 Survey 1.4.3* are to be in accordance with Pt 1, Ch 3, *Pt 1, Ch 3, 9 Ships for liquefied gases, Pt 1, Ch 3, 11 Machinery surveys - General requirements, Pt 1, Ch 3, 14 Electrical equipment* and *Pt 1, Ch 3, 19 Inert gas systems* of the Rules for Ships as applicable.

1.4.4 In addition to the survey and certification of equipment required by relevant Sections of the Rules for Ships and the Rules for Ships for Liquefied Gases, the major items of equipment included within the regasification system are required to be constructed under survey at the manufacturer's premises. These include, but are not limited to, vaporisers, heating medium heaters and their circulating pumps, LNG booster pumps and gas compressors.

1.4.5 Where the **✱ Lloyd's RGP+** notation is applied, the means of providing continuing operation in the event of a single failure, as demonstrated in the dependability assessment, see *Ch 1, 3.3 System dependability*, is to be examined and tested to ascertain that the system will continue to operate.

1.4.6 The condition of the regasification system shall be maintained to conform with the provisions of these Rules to ensure that the system remains fit to operate without danger to the ship, system or persons or without presenting unreasonable threat of harm to the marine environment.

1.4.7 After any survey of the regasification system under *Ch 1, 1.4 Survey 1.4.2* has been completed, no change should be made in the structure, equipment, fittings, arrangements and material covered by the survey, without the sanction of LR, except by direct replacement.

1.4.8 Wherever an accident occurs to a regasification system or a defect is discovered, either of which affects the safety of the ship or regasification system, the efficiency or completeness of its life-saving appliances or other equipment covered by these Rules, the Master or Owner of the ship should report at the earliest opportunity to LR, who should cause investigations to be initiated to determine whether a survey, as required by *Ch 1, 1.4 Survey 1.4.2.(e)*, is necessary.

1.4.9 Unless they form part of the classed equipment, surveys will not include those systems which are additional to the send-out process plant equipment, such as blending facilities, odorisers, dew point correction/dehumidification, except where the design and/or arrangements of such equipment and piping may affect the safety of the vessel.

1.5 Definitions

1.5.1 **Area** means a defined location. An area can be on open deck. An area can be open, semi-enclosed or enclosed. An area can be a space below deck. An area can be hazardous or non-hazardous.

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1.5.2 **Blowdown** is defined as the depressurisation of a system, part of a system and its equipment to allow the safe disposal of both vapour and liquid discharged from blowdown valves. Depressurisation is used to mitigate the consequences of a pipeline or vessel leak by reducing the leakage rate and/or inventory within the pipe or vessel prior to a potential failure.

1.5.3 **Dependability** is as defined in IEC 60050(191): *Quality vocabulary — Part 3: Availability, reliability and maintainability terms — Section 3.2: Glossary of international terms*. It is the collective term used to describe the availability performance and its influencing factors: reliability performance, maintainability performance and maintenance support performance and relates to essential services as agreed with Lloyd's Register.

Note Dependability is used only for general descriptions in non-quantitative terms.

1.5.4 **Enclosed space** is any space within which, in the absence of artificial ventilation, the ventilation will be limited and any explosive atmosphere will not be dispersed naturally. In practical terms, this is a space bounded either on all sides, or all but one side, by bulkheads and decks irrespective of openings, such that the required ventilation rate to prevent the accumulation of pockets of stagnant air cannot be achieved by natural ventilation alone.

1.5.5 **Essential Services** are:

- those systems, sub-systems and equipment required to provide continued safe operation of the Regasification System; and
- as defined by Pt 6, Ch 2, 1.6 Definitions 1.6.1 of the Rules for Ships.

1.5.6 **Gasification** is the process of heating a saturated vapour (LNG) by the addition of heat from an external source, above its saturation temperature.

1.5.7 **Gas Dangerous Space** is as defined in the Rules for Ships for Liquefied Gases.

1.5.8 **Hazardous area** is as defined in IEC 60079-10-1: Explosive atmospheres - Part 10-1: Classification of areas - Explosive gas atmospheres.

1.5.9 **High pressure** refers to systems, equipment and components containing LNG with a design pressure greater than 10 bar.

1.5.10 **Novel design**: designs of machinery and engineering systems that are considered by LR to be unconventional.

1.5.11 A **reasonably foreseeable abnormal condition** is an event, incident or failure that:

- has happened and could happen again;
- is planned for (e.g. emergency actions cover such a situation, maintenance is undertaken to prevent it, etc.).

1.5.12 **Regasification System** is the complete gasification process plant from LNG cargo storage tanks to the gas export (send-out) shore connection including regasification unit, suction drum, associated pumping, piping and ancillary systems.

1.5.13 **Regasification Unit** is referring to vaporisers, heaters, LNG booster pump and associated piping intended for the gasification of LNG from the cargo storage tanks.

1.5.14 **Risk assessment** is the evaluation of likelihood and consequence together with a judgement on the significance of the result, see IEC/ISO 31010: *Risk management, risk assessment techniques*.

1.5.15 **Risk**: the combination of the likelihood of an event and its consequence. Likelihood may be expressed as a probability or a frequency.

1.5.16 **Send-Out** is the discharge of the high pressure gas after the vaporisation and heating process. Send-out may include additional processes, such as trim heating, calorific correction, odourisation, or dew point correction/dehumidification.

1.5.17 **Vaporisation** is the controlled boiling of a liquid (in this case LNG) due to the addition of heat from an external source.

1.5.18 Other appropriate definitions as indicated in the Rules for Ships and the Rules for Ships for Liquefied Gases.

■ Section 2 Submission of plans and documentation

2.1 General

2.1.1 Documentation, together with the relevant information as detailed in this Section, shall be submitted for consideration.

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2.1.2 Any alterations to basic design, construction, materials, manufacturing procedure, equipment, fittings or arrangements of the process shall be re-submitted for approval before the regasification plant is put into operation.

2.2 Systems and arrangements

2.2.1 The plans and information required by relevant Sections of the Rules for Ships and the Rules for Ships for Liquefied Gases.

2.2.2 System description document: a description of the arrangements and the intended operating capability, design criteria and functionality of the regasification system in the context of the proposed service profile. It shall include the following information:

- (a) particulars of piping arrangements and control systems, including material specifications, design pressure, design temperature, and design ambient weather conditions;
- (b) operating design criteria that may include, as applicable:
 - (i) design maximum throughput and turn-down ratio in both open and closed loop operation. For closed loop operation, the maximum available heat input is also to be stated;
 - (ii) design maximum discharge pressure and minimum gas superheat temperature for the regasification system;
 - (iii) the maximum and minimum permissible variations from the design conditions;
 - (iv) the maximum permissible back pressure occurring in the discharge pipeline;
 - (v) design maximum transfer rates where ship-to-ship transfer is involved and the method and control used to handle boil-off gas and displacement gas to and from the offloading vessel;
 - (vi) the minimum required gas output for a specific sea-water temperature and throughput, as applicable;
 - (vii) the maximum LNG throughput at various sea-water inlet temperatures;
 - (viii) the design minimum temperature and throughput of the heated water or heat transfer fluid;
 - (ix) the output of the boiler or alternative heating arrangement;
 - (x) the minimum allowable sea-water outlet temperature.
- (c) procedures for connecting/disconnecting the gas send-out and LNG cargo hose, isolation arrangements and inerting and gas-freeing of the transfer lines;
- (d) emergency procedures to be followed during regasification and ship-to-ship operations. These shall include guidance on procedures to be followed in the event of sudden closure of the land-based send-out gas master valve;
- (e) operational maintenance procedures for the propulsion machinery and all other equipment and components usually used during navigation of the LNG ship which will remain on 'stand-by' or in 'cold' condition to allow the machinery and equipment to remain in a suitable condition to be reactivated without significant delay in the event of emergency departure or planned relocations of the ship;
- (f) specified and achievable levels of availability.

2.2.3 Risk based analysis undertaken to a recognised Standard in accordance with LR's ShipRight procedure 'Assessment of Risk Based Designs' and the associated Annex on LNG. The analysis shall be documented so that the risks and how they are eliminated or mitigated are clearly identified, and an appropriate level of safety, dependability and hazardous area classification is demonstrated.

2.2.4 Regasification system general arrangement. Plans showing the general arrangement of all areas where equipment, components and piping systems are located.

2.2.5 Plans for vaporisers, heat exchangers (shell/tube, printed circuit and plate type), LNG drum, liquid receivers and other pressure vessels (see also Pt 5, Ch 11 Other Pressure Vessels of the Rules for Ships).

2.2.6 Plans and documents as required by Pt 6, Ch 1 Control Engineering Systems of the Rules for Ships, showing the automatic controls, alarms and safety systems within the regasification system.

2.2.7 The thermodynamic calculations confirming the design send-out rates for the vaporisers.

2.2.8 Capacity calculations for pressure relief valves and discharge pipe vent stack pressure drop calculations.

2.2.9 Piping information is to include:

- (a) schematic plans, including full particulars of piping and instrumentations for:
 - (i) low and high pressure LNG supply pipework;
 - (ii) primary and secondary thermal fluid systems;
 - (iii) heating system for closed loop operation;
 - (iv) depressurisation system (knock-out drum or shock load verification arrangements);

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- (v) ship-to-ship manifold and transfer arrangements;
 - (vi) high pressure gas send-out systems;
 - (vii) cooling water systems;
 - (viii) other associated ancillary systems.
 - (b) details of means of draining, inerting, and gas-freeing of the regasification pipework, equipment and components;
 - (c) installation and insulation arrangements;
 - (d) protection of ship structure, ship systems and equipment against cryogenic leakage;
 - (e) pipe stress analysis. A complete stress analysis as required by the Rules for Ships for Liquefied Gases of the LNG and gas piping systems, including the gas send-out manifold. It shall take into account the weight of pipes, contents, insulation, accelerations (e.g. due to ship motions if significant), internal pressure, thermal contraction, shock loads due to depressurisation, and loads induced by hog and sag of the ship for each branch of the piping system.
- 2.2.10 Hazardous Area Plan for regasification equipment and send-out system.
- 2.2.11 Interfaces: plans and documents detailing the ship to regasification system interfaces.
- 2.2.12 Safety system plans: fire-fighting details, gas detection details, fire and general alarm details, all related to the additional regasification system and to the send-out arrangements. They shall be included in the main safety system plans of the vessel for approval in accordance with the Rules for Ships for Liquefied Gases.
- 2.2.13 Escape plan: details of the arrangements for safe escape protection in relation to the additional regasification system and to the send-out arrangements.
- 2.2.14 An emergency shutdown (ESD) system cause and effect matrix that shall cover the additional operational scenarios of regasification and ship-to-ship transfer. This shall be integrated with the ESD main system matrix of the vessel. Where an ESD initiation results in multiple actions, the matrix shall indicate these in the order in which they will be performed.
- 2.2.15 A functional flow chart of the ESD system and connected systems shall be provided, which aligns with the cause and effect matrix and details the functions provided by the ESD System. This shall be retained on board at the cargo control station and on the navigation bridge.
- 2.2.16 A process shutdown (PSD), cause/effect matrix and design philosophy.
- 2.2.17 Details of depressurisation and high pressure blow-down philosophy and arrangements.
- 2.2.18 Ancillary systems or additional equipment such as blending facilities, odorisers, dew point correction/ dehumidification, control and monitoring facilities where these are to be considered as part of the classed equipment.
- 2.2.19 Operating manuals shall be submitted. The content of the manuals shall include but not be limited to:
- (a) particulars and a description of the systems;
 - (b) overall operation of the system, including procedures for planned start-up and shutdown;
 - (c) maintenance instructions for the installed equipment, systems and arrangements;
 - (d) temperature and pressure control systems;
 - (e) system limitations, including minimum temperatures, maximum pressures, transfer rates;
 - (f) special procedures associated with fire-fighting where different from ship systems;
 - (g) details of fixed gas detection where different from ship fitted systems;
 - (h) control, alarm and safety systems;
 - (i) emergency and process shutdown systems, including pressure relief and blowdown;
 - (j) emergency procedures, including isolation from cargo tank.

■ Section 3

Risk based analysis

3.1 Purpose

3.1.1 The purpose of the risk based analysis is to:

- (a) evaluate safety considerations that are specific to the regasification and send-out equipment, see *Ch 1, 3.2 System safety risk assessment*;

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- (b) evaluate dependability of the regasification plant, see *Ch 1, 3.3 System dependability*;
- (c) specially consider arrangements which deviate from the requirements of these Rules, see *Ch 1, 3.2 System safety risk assessment*.

3.2 System safety risk assessment

3.2.1 The objectives of the assessment are to:

- (a) evaluate safety risks associated with the use of the regasification system where the requirements within these Rules are not satisfied;
- (b) evaluate safety risks associated with the use of the regasification system where specifically required by these Rules;
- (c) for *Ch 1, 3.2 System safety risk assessment 3.2.1* and *Ch 1, 3.2 System safety risk assessment 3.2.1.(b)*, demonstrate that an appropriate level of safety is achieved, which is commensurate with that generally accepted for the transportation of LNG cargoes through compliance with LR's Rules for Ships for Liquefied Gases.

3.2.2 Where the risks cannot be eliminated, an inherently safer design shall be sought in preference to operational/ procedural controls. This shall focus on engineered prevention of failure (e.g. a minimised number of connections, increased reliability, and redundancy).

3.2.3 The risk assessment may identify the requirement for safety measures in addition to those specifically stated in these Rules.

3.2.4 The scope of the risk assessment may include but not be limited to:

- (a) normal operation, start-up, normal shutdown, non-use, and emergency shutdown of the system, including:
 - pressurised gas discharge to shore;
 - high pressure gas venting;
 - storage and handling of flammable refrigerants (as applicable);
 - continuous presence of liquid and vapour cargo outside the cargo containment system;
 - ship-to-ship transfer of liquid cargo.
- (b) physical equipment layout, machinery and equipment layout, arrangements and location, including extension of hazardous areas and evacuation arrangements;
- (c) fire and explosion, process upset conditions, over-pressure and under-pressure, mechanical and electrical failures and human error.

3.2.5 The risk assessment shall be undertaken by suitably qualified and experienced individuals to a recognised Standard (e.g. as outlined in ISO/IEC 31010-2009: *Risk management – Risk assessment techniques*) in accordance with LR's ShipRight Procedure *Assessment of Risk Based Designs* and the associated Annex on LNG.

3.2.6 The risk assessment shall specifically address the following aspects:

- (a) fire and explosions in areas or spaces containing piping, machinery, equipment and components;
- (b) fire and explosions adjacent to areas or spaces containing piping, machinery, equipment and components;
- (c) cryogenic leakage from piping, equipment and components associated with the regasification system;
- (d) corrosion/erosion in gas high pressure piping, components and tanks associated with the regasification system;
- (e) mechanical failure in regasification machinery, equipment or components;
- (f) control/electrical failure in regasification machinery, equipment or components;
- (g) manufacturing defects in equipment and machinery;
- (h) human error in operation, maintenance, inspection and testing of regasification machinery, equipment and components;
- (i) location of piping, machinery, equipment and components;
- (j) cargo tanks over-pressure and under-pressure situations associated with the regasification and ship-to-ship transfer operations;
- (k) analysis of risk associated with the ship-to-ship LNG transfer in accordance with ISO 28460:2010 *Petroleum and natural gas industries – Installation and equipment for liquefied natural gas – Ship-to-shore interface and port operations* and the relevant parts of EN 1474 as applicable, and SIGTTO LNG *Ship-to-Ship Transfer Guidelines*;
- (l) process upsets associated with the land-based receiving systems;
- (m) jet fires and blast.

3.2.7 Where a risk assessment or study of similar intent is utilised within these Rules, the results shall also include, but not be limited to, the following as evidence of effectiveness:

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- (a) description of methodology and standards applied;
- (b) potential variation in scenario interpretation or sources of error in the study;
- (c) validation of the risk assessment process by an independent and suitable third party;
- (d) quality system under which the risk assessment was developed;
- (e) the source, suitability and validity of data used within the assessment;
- (f) the knowledge base of persons involved within the assessment;
- (g) system of distribution of results to relevant parties; and
- (h) validation of results by an independent and suitable third party.

3.3 System dependability

3.3.1 Where Class Notation **✱ Lloyd's RGP+** is to be applied, an assessment shall be carried out to demonstrate that a fault in any active component or system will not result in reduced availability of the plant to regasify the LNG cargo and send-out gas.

3.3.2 The level of availability of the regasification system shall be specified by the Owner, see *Ch 1, 2.2 Systems and arrangements 2.2.2*.

3.3.3 The assessment shall be undertaken by suitably qualified and experienced individuals using approaches acceptable to LR.

■ Section 4

System design

4.1 General

4.1.1 Materials, components and equipment to be used in the construction of regasification systems shall be suitable for the intended service conditions and acceptable to LR. The materials, components and equipment shall also satisfy the requirements of this Section.

4.1.2 Materials shall comply with the requirements of the *Rules for the Manufacture, Testing and Certification of Materials* (hereinafter referred to as the Rules for Materials) and *Chapter 6* of the Rules for Ships for Liquefied Gases.

4.1.3 The design, arrangements and selection of equipment shall be such as to minimise the risk of fire and explosion from flammable products.

4.1.4 Electrical components and equipment shall comply with *Ch 1, 7 Electrical installation*.

4.1.5 Any single failure of the regasification system shall not result in a hazard that affects safety.

4.1.6 The regasification ship or barge shall have adequate capability for managing the boil-off gas generated by heat ingress through headers, manifolds and loading arms during ship-to-ship transfer operations.

4.1.7 The regasification system shall include provision to pre-cool the product transfer piping system prior to ship-to-ship transfer operations commencing.

4.2 Vaporisers

4.2.1 The requirements of these Rules apply to various types of vaporiser, such as:

- **STV** – Shell and tube heat-exchanger type.
- **ORV** – Open rack type utilising sea-water or a circulating intermediate heated fluid.
- **SCV** – Submerged combustion type utilising the heat of combustion of either oil or send-out gas.

4.2.2 Vaporising units of novel design, making use of materials not covered by the Rules, will be subject to special consideration and subject to the requirements of *Pt 7, Ch 14 Requirements for Machinery and Engineering Systems of Unconventional Design* of the Rules for Ships, 'Requirements for machinery and engineering systems of unconventional design'.

4.2.3 The manufacture, installation and testing of vaporisers, including the intermediate heat transfer vessels and pumping systems, shall be undertaken in accordance with the requirements of the Rules for Ships for Liquefied Gases.

4.2.4 All LNG high pressure pumps supplying vaporisers, which are capable of developing a pressure exceeding the design pressure of the system into which they are pumping, are to be provided with relief valves in closed circuit.

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4.2.5 For STVs and ORVs, sea-water may be used as a primary heat source for vaporisation. An intermediate heat transfer fluid may be proposed to reduce the chance of freezing and effects of corrosion.

4.2.6 Where sea-water is used as the source of heat to vaporise the LNG, the tubes shall be manufactured from a corrosion-resistant material, taking into consideration the type and temperature of media conveyed. Where the ✕ **Lloyd's RGP+** Notation is to be assigned, suitable redundancy of the sea-water circulation pump and LNG high pressure supply pumps shall be provided.

4.2.7 When an intermediate heat transfer fluid is used, and where the ✕ **Lloyd's RGP+** Notation is to be assigned, dual compressors or circulating pumps shall be provided. Where the heat transfer fluid goes through a phase change, the applicable Sections of *Pt 6, Ch 3 Refrigerated Cargo Installations* of the Rules for Ships shall be complied with.

4.2.8 Where potential risk of failure of a tube or passage could result in gas entering the sea-water side:

- (a) the sea-water side shall be designed to accept the full gas pressure of the gas side;
- (b) the sea-water side shall be protected with relief valves in readily visible positions; the discharge from these relief valves shall be taken to a suitable high-pressure venting arrangement and the number and position of valves shall be adequate to relieve the flow occurring due to failure of a single tube.

4.2.9 If steam is used in a heat exchanger containing either propane or other gas, the condensate shall not be passed directly back to the engine room. The condensate shall be passed through a degassing tank located in a gas-dangerous area. The vent outlet from the degassing tank shall be routed to a safe location and be fitted with a flame screen. The degassing tank shall be covered by the gas detection and alarm system, see *Ch 1, 4.3 Gas detection system*.

4.2.10 If the LNG ship is to operate in regions where insufficient natural sources of heat are available for vaporisation, e.g. low sea-water temperature, the design gas output conditions shall be maintained utilising alternative means.

4.2.11 Where alternative means of heating the LNG are required, an independent gas or oil supply system shall be provided to facilitate initial start-up.

4.2.12 The regasification system may operate with a dual heat source with, for example, a mixture of heat inputs from sea-water and a boiler.

4.2.13 Where aluminium alloy vertical tubes and horizontal headers are constantly covered with sea-water, adequate protection against corrosion shall be provided.

4.2.14 Commissioning and testing of vaporisers shall be undertaken by the manufacturer prior to units being installed on board.

4.2.15 Water supply pumps shall be fitted with suitable inlet filters. It shall be possible to remove and clean the filters whilst the regasification system remains operational. Any regasification system-related sea-water inlet shall be fitted with gratings and provision made to allow cleaning by low pressure steam or compressed air.

4.2.16 A water treatment system shall be incorporated for use with submerged combustion vaporisers to eliminate degradation of the tubes.

4.2.17 The submerged combustion vaporisers shall comply with the relevant Sections applicable to inert gas generators and steam boilers operating with boil-off gas, as applicable, stated in *Chapter 7* of the Rules for Ships for Liquefied Gases and Part 5, *Pt 5, Ch 10 Steam Raising Plant and Associated Pressure Vessels*, *Pt 5, Ch 14 Machinery Piping Systems* and *Pt 5, Ch 15 Piping Systems for Oil Tankers* of the Rules for Ships.

4.3 Gas detection system

4.3.1 In addition to the gas detection system fitted to allow compliance with the Rules for Ships for Liquefied Gases, a permanently installed system of gas detection and audible and visual alarms is to be fitted in:

- (a) all enclosed spaces containing gas piping, liquid piping or regasification equipment;
- (b) other enclosed or semi-enclosed spaces where gas vapours may accumulate;
- (c) air-locks;
- (d) secondary fluid expansion tanks;
- (e) the condensate degassing tank.

4.3.2 Gas detection equipment is to be designed, installed and tested in accordance with IEC 60079-29-1, and is to be suitable for the gases to be detected.

4.3.3 The number and the positions of detection heads or sampling heads is to be determined with due regard to the size and layout of the compartment, the air flow from compartment purging or ventilation and stagnant areas, and the manufacturer's recommendations.

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4.3.4 The gas detection system serving the regasification system may be either independent or combined with the gas detection system installed to allow compliance with the Rules for Ships for Liquefied Gases.

4.3.5 The gas detection is to be of the continuous monitoring type, capable of immediate response.

4.3.6 The gas detection system serving the regasification system is otherwise to comply with the construction and installation requirements of the Rules for Ships for Liquefied Gases.

4.4 Emergency shutdown (ESD) system

4.4.1 An emergency shutdown (ESD) system serving the regasification systems and equipment shall be fitted and shall comply with the cause and effect matrix shown in *Table 1.4.1 ESD functional arrangements*, as applicable.

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Table 1.4.1 ESD functional arrangements

	Pumps		Compressor systems				Valves	Link
Shutdown action	Cargo pumps/ cargo booster pumps	Spray/ stripping pumps	Vapour return compressors	Fuel gas compressors	Reliquefaction plant, including condensate return pumps, if fitted	Gas combustion unit	ESD valves Valves	Signal to ship/ shore link***
Initiation								
Emergency push buttons (See Ch 1, 4.4 Emergency shutdown (ESD) system 4.4.2)	√	√	√	See Note 2	√	√	√	√
Fire detection on deck or in compressor house*	√	√	√	√	√	√	√	√
High level in cargo tank	√	√	√	See Notes 1 and 2	See Notes 1 and 3	See Note 1	See Note 6	√
Signal from ship/shore link	√	√	√	See Note 2	See Note 3	n/a	√	n/a
Loss of motive power to ESD valves**	√	√	√	See Note 2	See Note 3	n/a	√	√
Main electric power failure ('blackout')	See Note 7	See Note 7	See Note 7	See Note 7	See Note 7	See Note 7	√	√
Cargo tank level alarm override (See Note 4)	See Note 4	See Notes 4 and 5	√	See Note 1	See Note 1	See Note 1	√	√
KEY * Fusible plugs, electronic point temperature monitoring or area fire detection may be used for this purpose on deck ** Failure of hydraulic, electric or pneumatic power for remotely operated ESD valve actuators *** Signal need not indicate the event initiating ESD √ Functional requirement								

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n/a	Not applicable
<p>Note 1. These items of equipment can be omitted from these specific automatic shutdown initiators provided the compressor inlets are protected against cargo liquid ingress.</p> <p>Note 2. If the fuel gas compressor is used to return cargo vapour to shore, it shall be included in the ESD system only when operating in this mode.</p> <p>Note 3. If the reliquefaction plant compressors are used for vapour return/shore line clearing, they shall be included in the ESD system only when operating in that mode.</p> <p>Note 4. An override of the overflow control system may be used at sea to prevent false alarms or shutdowns. The arrangements for the override system shall be such that inadvertent operation is prevented. When level alarms are overridden, operation of cargo pumps and the opening of manifold ESD valves shall be inhibited and continuous visual indication shall be given at the relevant control station(s) and the navigating bridge.</p> <p>Note 5. Cargo spray or stripping pumps used to supply forcing vaporiser may be excluded from the ESD system only when operating in that mode.</p> <p>Note 6. A sensor operating independently of the high liquid level alarm shall automatically actuate a shut-off valve in a manner that will both avoid excessive liquid pressure in the loading line and prevent the tank from becoming liquid full. These sensors may be used to close automatically the tank filling valve for the individual tank where the sensors are installed, as an alternative to closing the ESD valve provided at each manifold connection. If this option is adopted, activation of the full ESD system shall be initiated when the high-level sensors in all the tanks to be loaded have been activated.</p> <p>Note 7. These items of equipment shall be designed not to restart automatically upon recovery of main electric power and without confirmation of safe conditions.</p>	

4.4.2 The ESD system shall be activated by the manual and automatic inputs listed in *Table 1.4.1 ESD functional arrangements*. Any additional inputs shall only be included in the ESD system if it can be shown that their inclusion does not reduce the integrity and reliability of the system overall.

4.4.3 The ESD system shall return the regasification system to a safe static condition, allowing remedial action to be taken. Due regard shall be given in the design of the ESD system to avoid the generation of surge pressures within the pipework.

4.4.4 The equipment to be shut down on ESD activation shall include manifold valves during loading or discharge, and pumps and compressors associated with transferring cargo in either liquid or gaseous state.

4.4.5 The emergency shutdown system associated with the regasification system shall be designed, manufactured and tested in accordance with the principles stated in Ch 5, 5.6 of the Rules for Ships for Liquefied Gases.

4.4.6 The number and location of additional shutdown positions shall be determined by the type, number, location and position of the regasification systems and equipment.

4.5 Process shutdown (PSD) system

4.5.1 A process shutdown (PSD) system for the regasification system shall be arranged in accordance with the requirements listed in *Ch 1, 6 Instrumentation, control, alarm and monitoring systems*.

4.5.2 The activation of the PSD shall stop the supply of LNG to the LNG suction drum, high pressure LNG pumps and gas discharge valve. Where the installation comprises a number of separate regasification systems the PSD may be system-specific as well as full shutdown. A PSD functional arrangement matrix commensurate with that shown in *Table 1.4.1 ESD functional arrangements* shall be provided.

4.5.3 Manual PSD points shall be arranged at the regasification system control station and at locations as determined by the type, number, location and position of the regasification systems and equipment. The process shutdown points shall be clearly visible.

4.5.4 Process shutdown valves in liquid piping shall close fully under all service conditions within 30 seconds of actuation. Information about the closing time of the valves and their operating characteristics shall be available on board and the closing time shall be verifiable and reproducible.

4.5.5 The closure time of 30 seconds for the shutdown valve referred to in *Ch 1, 4.5 Process shutdown (PSD) system* 4.5.4 shall be measured from the time of manual or automatic initiation to final closure. This is called the total shutdown time and is made up of a signal response time and a valve closure time. The valve closure time shall be such as to avoid surge pressure in pipelines. Valves shall close smoothly.

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4.6 Depressurisation and blowdown system

4.6.1 A depressurisation and blowdown system shall be provided for depressurising the high pressure liquid and gas pumps, vessels and pipework.

4.6.2 Where a liquid depressurisation system is provided, adequate provision shall be made in the design and installation for the effects of back pressure in the system and vapour flash-off when the pressures of liquids in the blowdown system are reduced.

4.6.3 Manual and automatic activation of the depressurisation system shall be provided.

4.6.4 Manual activation shall be possible from the regasification control station, at the send-out manifold, and from other locations as determined by the type, number, location and position of the regasification systems and equipment.

4.6.5 Automatic activation shall be part of the emergency shutdown arrangements.

4.7 Pressure relief and venting system

4.7.1 Each regasification unit shall be provided with dedicated high pressure safety relief valves and venting arrangements. The arrangements shall be independent from the venting arrangements serving the cargo tanks. High pressure safety relief valves, headers, knock-out/drain drum and vent masts shall be located within the cargo deck area.

4.7.2 High pressure safety relief valves and venting arrangements for liquid and gas phases shall be provided for each regasification system. The safety relief valve support arrangements shall withstand the loads imposed by discharges.

4.7.3 Where multiple regasification systems are installed, the design of pressure safety relief and venting arrangements shall consider the maximum combined release rate.

4.7.4 The gaseous phase safety relief valves shall be led to the dedicated high pressure vent mast for the regasification system required by *Ch 1, 4.7 Pressure relief and venting system 4.7.1*. The high pressure vent mast shall be sized to handle the maximum regasification capacity and to ensure safe dispersal of the gas.

4.7.5 The liquid phase safety relief valves shall be led to a knock-out/drain drum having adequate capacity for the maximum LNG inflow anticipated within the design of the regasification unit. The knock-out drum shall be fitted with a level switch to stop all high pressure LNG pumps. Any LNG from the vent knock-out drum shall be safely drained or be allowed to boil off and vapour to be returned to the ship's vapour header.

4.7.6 LNG suction and LNG knock-out/drain drums shall be fitted with pressure safety relief valves in accordance with the Rules for Ships for Liquefied Gases.

4.7.7 Pressure safety relief valves and venting arrangements and locations shall comply with *Ch 8 Vent Systems for Cargo Containment* of the Rules for Ships for Liquefied Gases.

4.8 Fire protection and fire extinction

4.8.1 The regasification system shall be protected with both a water spray deluge system plus a dry chemical powder system and a fire detection system. The systems shall meet the requirements of *Chapter 11* of the Rules for Ships for Liquefied Gases.

4.8.2 The water spray deluge system and dry chemical powder system installed on board the ship shall be capable of providing coverage for the areas defined in *Chapter 11* of the Rules for Ships for Liquefied Gases and the regasification system simultaneously.

4.8.3 The ship's water spray deluge system shall be designed to cover the regasification equipment, ship-to-ship LNG loading arms and export manifold.

4.8.4 Protection from fire and heat shall be provided as necessary for the safe escape of personnel in case of an emergency. Details shall be submitted for appraisal as indicated in *Ch 1, 2 Submission of plans and documentation*.

4.8.5 Fire protection arrangements shall be such as to prevent possible jet fires propagating from the regasification unit to the adjacent cargo tank areas. Proposed arrangements shall be evaluated in the risk based studies in *Ch 1, 3 Risk based analysis*.

4.9 Location and arrangement of equipment

4.9.1 The location of the regasification unit shall be considered part of the cargo area as defined in *Ch 1, 1.3.6* of the Rules for Ships for Liquefied Gases. The regasification unit and all its associated equipment shall be located as far as is reasonably possible from the accommodation spaces.

4.9.2 The regasification system machinery may be located on the open deck or in cargo pump and cargo compressor rooms. Arrangements of such spaces shall be in accordance with the requirements of *Chapter 3* of the Rules for Ships for Liquefied Gases.

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4.9.3 When the regasification units are located on open deck they shall be placed in a sheltered location protected from green water.

4.9.4 The locations of the system arrangements, including vaporisers, high pressure pumps, suction drums, heaters, liquid pumps and ancillary piping systems, shall be defined and evaluated in the system safety risk assessment, (see *Ch 1, 3 Risk based analysis*), and shall be acceptable to LR.

4.9.5 The ship structure shall be protected from possible cryogenic spills at the regasification unit and suction drum in way of fittings, fixtures and demountable joints except in those locations where the structure material can withstand cryogenic temperatures.

■ Section 5

Piping requirements

5.1 General

5.1.1 Regasification system piping shall meet the applicable requirements of *Ch 5 Process Pressure Vessels and Liquid, Vapour and Pressure Piping Systems* of the Rules for Ships for Liquefied Gases and *Pt 5, Pt 5, Ch 12 Piping Design Requirements, Pt 5, Ch 13 Ship Piping Systems* and *Pt 5, Ch 14 Machinery Piping Systems* of the Rules for Ships.

5.1.2 All piping, valves and fittings shall be suitable for the operating and environmental conditions.

5.2 Materials

5.2.1 All materials used in the piping systems shall be suitable for use with the intended medium, service and ambient conditions, and shall comply with the applicable requirements of *Chapter 6* of the Rules for Ships for Liquefied Gases and of *Pt 5, Ch 12 Piping Design Requirements* of the Rules for Ships.

5.3 Piping design

5.3.1 Piping between the LNG ship cargo system and the regasification system shall be equipped with a manually operated stop valve and a remotely controlled emergency shut-down valve. These valves shall be located as close to the tank as practicable. When the regasification unit is located in the forward section of the ship, such isolation shall be as near as possible to the boundary of the forwardmost cargo tank bulkhead and within the cargo area.

5.3.2 Dry break quick-release connectors shall be provided for use in an emergency in:

- (a) piping between an LNG supply ship and the regasification system;
- (b) send-out gas piping between a regasification ship and receiving terminal.

5.3.3 A manually operated shut-off terminal valve shall be provided at the send-out manifold, in addition to any other automatic shut-off valves required by the Rules for Ships for Liquefied Gases.

5.3.4 The spool piece, reducers, valves and other fittings to which the cargo system or the send-out system is directly connected shall be of approved material. They shall be of robust construction, adequately supported and suitable for the stated design conditions and manifold forces. For LNG transfer, attention is drawn to SIGTTO '*Manifold Recommendations for Liquefied Gas Carriers*'.

5.3.5 Means of purging, inerting and gas-freeing the pipe lines used for the regasification system shall be provided.

5.3.6 Means for mechanical separation shall be provided between the regasification piping system and the ship's inert gas and nitrogen systems.

5.3.7 All main isolating valves serving the regasification systems and equipment shall be located in a readily accessible location.

5.3.8 The fabrication and installation of the piping associated with the regasification system and its ancillary systems shall be in accordance with the relevant Sections of the Rules for Ships and the Rules for Ships for Liquefied Gases to the satisfaction of the Surveyor.

5.3.9 Provisions shall be incorporated in the design to minimise the number of flanged connections. In order to protect personnel from cryogenic burns and prevent ship structure or other carbon steel structures on deck from being exposed to brittle fracture due to LNG pressure jet, consideration shall be given to the fitting of spray shield arrangements to any flanged connection of piping containing LNG at a pressure above 10 bar.

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5.3.10 Where applicable, all LNG pipework servicing the regasification system shall be suitably insulated and shall be covered with an efficient vapour barrier.

5.3.11 All low and high pressure LNG supply pipework serving the regasification systems is to be subject to a stress analysis, taking into account all the stresses due to weight of pipes, including acceleration loads if significant, internal pressure, thermal contraction and loads induced by hog and sag of the ship for each branch of the piping system.

5.4 Piping system testing and non-destructive examination

5.4.1 Testing and non-destructive examination of the regasification unit, LNG and gas piping systems shall comply with the relevant requirements of *Pt 5, Ch 12, 9 Piping for LPG/LNG carriers, gas fuelled ships and classed refrigeration systems* of the Rules for Ships and *Ch 5 Process Pressure Vessels and Liquid, Vapour and Pressure Piping Systems* of the Rules for Ships for Liquefied Gases.

5.4.2 All piping systems shall be subjected to a hydrostatic test to at least 1,5 times the design pressure. When piping systems or parts of systems are completely manufactured and equipped with all fittings, the hydrostatic test may be conducted prior to installation aboard ship. Joints welded on board shall be hydrostatically tested to at least 1,5 times the design pressure. Where water cannot be tolerated or the piping cannot be dried prior to putting the system into service, proposals for alternative testing fluids or testing means shall be submitted for special consideration by the Surveyor.

5.4.3 After assembly on board, all cargo and process piping shall be subjected to a leak test using air, halides or other suitable medium to a pressure dependant on the leak detection method applied.

5.4.4 All piping systems including valves, fittings and associated equipment for handling cargo or vapours shall be tested under normal operating conditions not later than at the first regasification operation.

■ Section 6

Instrumentation, control, alarm and monitoring systems

6.1 Functional objectives

6.1.1 The regasification system shall be provided with appropriate controls for safe operation of the system with adequate alerts and safeguards.

6.2 Performance requirements

6.2.1 Instrumentation, control, alarm and monitoring systems shall comply with the requirements of this Section and *Pt 6, Ch 1 Control Engineering Systems* of the Rules for Ships.

6.2.2 The system shall be provided with automatic and/or remote controls to ensure the system operates within its design parameters.

6.2.3 A system for monitoring and indicating alerts shall be provided.

6.2.4 The system shall be provided with safeguards which will operate to prevent a hazard occurring or to reduce an existing hazard to persons, machinery or the ship or the environment.

6.2.5 Locations at which the regasification system is controlled shall be provided with a means of communication with the gas-receiving terminal, *see Ch 1, 6.4 Communications*.

6.2.6 The regasification system shall be provided with control, monitoring, alert and safety systems that will maintain the system throughout all normal and reasonably foreseeable abnormal conditions.

6.2.7 The system shall be provided with the alarms and shutdowns as identified by the system manufacturer. In the absence of such guidance, the alarms and shutdowns indicated in these Rules may be used.

6.3 Control station

6.3.1 A control station for the regasification system and ship-to-ship operations shall be arranged within a non-hazardous area. Emergency procedures, as defined in Section 3 of these Rules, concerning regasification and ship-to-ship transfer operations shall be capable of being performed from this station.

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6.4 Communications

6.4.1 At least two means of communication shall be provided between the control station and the receiving terminal; one of these systems shall be independent of the main electrical supply.

6.4.2 Internal communication cables shall comply with the applicable requirements of the Rules for Ships.

6.4.3 The cable installation shall provide adequate protection against mechanical damage and electromagnetic interference.

6.4.4 Components shall be located with appropriate segregation such that the risk of mechanical damage or electromagnetic interference resulting in the loss of both active and stand-by components is minimised. Duplicated communication links and equipment shall be routed to give as much physical separation as is practicable.

6.5 Equipment and systems – Alarms, shutdowns and safeguards

6.5.1 Suitable interlocks shall be provided to prevent start-up of the regasification system under conditions which could hazard the system or its equipment and components.

6.5.2 The manufacturer shall identify the required alarms, shutdowns and safeguards for all vaporisers; the minimum required shutdowns are indicated in *Table 1.6.1 Alarms, shutdowns and safeguards for vaporisers*.

Table 1.6.1 Alarms, shutdowns and safeguards for vaporisers

Item	Alarm	Note
Gas discharge temperature	Very Low	Automatic shutdown
Sea-water (and heating medium) supply pressure	Very Low	Automatic shutdown
Indication of supply gas pressure to burner (SCV type)	Very Low	Automatic shutdown
Flame failure (SCV type)	Failure	Automatic shutdown
Indication of sump water level (SCV type)	Very Low	Automatic shutdown
Combustion air pressure (SCV type)	Low	Automatic shutdown
	High	Automatic shutdown
Flue gas temperature (SCV type)	High	Automatic shutdown
Gas leak detected		ESD operation (programmed)

Note 1. SCV type means submerged combustion vaporiser type.

Note 2. Any additional alarms and shutdowns identified during the Risk Assessment required in *Ch 1, 3 Risk based analysis* of these Rules are also to be provided.

Note 3. The Table contains the minimum list of alarms and shutdowns for a regasification plant; additional alarms and shutdowns may be necessary as determined through risk-mitigating activities in response to a completed Risk Assessment as required by *Ch 1, 3 Risk based analysis* of these Rules.

Note 4. If certain alarms and shutdowns are not applicable for the regasification system, sufficient evidence shall be produced to support the claim and shall form part of the Risk Assessment required by *Ch 1, 3 Risk based analysis* of these Rules.

6.5.3 The manufacturer shall identify required alarms, shutdowns and safeguards for the suction drum; the minimum shutdowns required are indicated in *Table 1.6.2 Alarms, shutdowns and safeguards for suction drums*.

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Table 1.6.2 Alarms, shutdowns and safeguards for suction drums

Item	Alarm	Note
Suction drum pressure	Low	Automatic shutdown
Suction drum level	Very low	Automatic shutdown
Suction drum level	Very high	Automatic shutdown
<p>Note 1. Any additional alarms and shutdowns identified during the Risk Assessment required by <i>Ch 1, 3 Risk based analysis</i> of these Rules are also to be provided.</p> <p>Note 2. The Table contains the minimum list of alarms and shutdowns for a regasification plant; additional alarms and shutdowns may be necessary as determined through risk-mitigating activities in response to a completed Risk Assessment as required by <i>Ch 1, 3 Risk based analysis</i> of these Rules.</p> <p>Note 3. If certain alarms and shutdowns are not applicable for the regasification system, sufficient evidence shall be produced and is to form part of the Risk Assessment required by <i>Ch 1, 3 Risk based analysis</i> of these Rules.</p>		

6.5.4 The control and monitoring arrangements shall be appropriate to enable the system to be controlled within the design parameters specified by the manufacturer.

Section 7

Electrical installation

7.1 Functional objectives

7.1.1 The electrical installation of a regasification system shall be designed, installed and maintained such that it does not represent an ignition hazard or introduce any foreseeable hazards into the normal operation of the ship.

7.2 Performance requirements

7.2.1 The installations shall meet with the requirements of *Pt 6, Ch 2 Electrical Engineering* of the Rules for Ships, or an alternative relevant National or International Standard acceptable to LR, as applicable.

7.2.2 All electrical equipment shall be suitably protected against damage to itself under fault conditions and to prevent injury to personnel.

7.3 System design, construction and installation

7.3.1 The electrical power for the regasification system shall be provided by an individual dedicated circuit from the main switchboard.

7.3.2 Where the ✖ **Lloyd's RGP+** Notation is assigned, the system shall be provided by two individual circuits separated in the main switchboard or section board and throughout its length and without the use of common feeders. Where a stand-by unit is provided, it shall be supplied from a separate section of the main switchboard to ensure a single point equipment failure does not render both systems inoperable.

7.3.3 Electrical equipment for the regasification system shall be suitable for use in the environmental conditions envisaged during regasification mode. It is also to be appropriately installed to prevent any adverse effects due to environmental conditions encountered when not in use, such as during navigation.

7.4 Hazardous zones and spaces

7.4.1 The classification of hazardous zones associated with the regasification plant shall be carried out in accordance with IEC 60079-10-1 or an alternative relevant National or International Standard acceptable to LR.

7.4.2 The hazardous zones plan shall identify areas where the release of flammable gases and vapours may be present due to the regasification system during normal working operation and reasonably foreseeable abnormal conditions, as identified during the Risk Assessments required by *Ch 1, 3 Risk based analysis* of these Rules.

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7.5 Certified safe type equipment

7.5.1 Selection of electrical equipment within the hazardous zones shall be in accordance with *Pt 6, Ch 2, 14 Electrical equipment for use in explosive gas atmospheres or in the presence of combustible dusts* of the Rules for Ships.

■ Section 8

Regasification testing and trials

8.1 Testing and trials prior to commissioning

8.1.1 During construction or conversion of the vessel, the following additional tests and trials for the regasification system shall be carried out:

- Pressure and leak test of LNG and gas piping.
- Suction drum leak test.
- Safety valves setting.
- Function tests of fire safety systems, emergency shutdown system, process shutdown system, gas detection system, depressurising and blowdown system.
- Function tests of control, monitoring, alert and safety systems.
- Regasification heating pumps function tests.
- Verification of the requirements derived from the Risk Analysis as required by *Ch 1, 3 Risk based analysis* of these Rules.

8.2 Commissioning regasification trials

8.2.1 The regasification trials program shall be prepared and submitted for approval. The regasification trial program shall include technical and operational information relevant to such testing.

8.2.2 Preliminary regasification trials shall consist of a running test of the regasification system with LNG low flow for the function test and shall be carried out after gas trials and before delivery.

8.2.3 The full capacity test of the regasification plant shall be carried out at an operational site.

8.2.4 The test and measurements shall be carried out at the proper time and according to the Rules and Regulations, manufacturer's standards and industry's best practice.

8.2.5 After completion of the regasification trials, a report shall be prepared and submitted. A copy of the report shall be retained on board.

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